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A METHOD FOR APPROXIMATING EQUIVALENT CORROSION TIME FROM EXPERIMENTAL DATA

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INFORMATION CATEGORY

UNCLASSIFIED

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DISCLAIMER

A METHOD FOR APPROXIMATING EQUIVALENT CORROSION TIME FROM EXPERIMENTAL DATA

In many development tests it becomes necessary to operate at conditions which can still be considered transient. Comparisons between tests at different test conditions resulting from modifications become difficult to interpret.

A FORTRAN program was written for a method of comparing equivalent corrosion time at a particular temperature level based on transient experimental temperature versus time data.

Assuming a rate reaction of graphite removal in the form of

$$dm/dt = - C_1 e^{-E/RT}$$

where

E = activation energy
R = gas constant
T = temperature
t = time
m = mass

a test of duration from t = 0 to t = to would produce

$$M_o - m = \int_{Mo}^{m} dm = \int_{0}^{to} C_1 e^{-E/RT} dt$$

where

$$T = f(t)$$

The same weight loss would occur for a fixed reference temperature, Tr, at a duration tr

$$C_1 e^{-E/RTr} \cdot tr = \int_{M_o}^{m} dm = \int_{0}^{to} C_1 e^{-E/RT} dt$$

or

$$tr = e^{E/RTr} \int_{0}^{to} e^{-E/RT} \cdot dt$$

or

$$tr = \int_{0}^{to} dt \cdot e^{\frac{E}{R}\left(\frac{1}{Tr} - \frac{1}{T}\right)}$$

where the reference temperature is Tr and the measured temperature is T.

From graphite corrosion measurements, the best value at present of E/R = B is:

$$\frac{30{,}000 \text{ cal/mole}}{1.987 \text{ cal/mole } ^{o}K} = 15{,}100^{o}K = 27{,}200^{o}R$$

Therefore, the last equation can be rewritten in dimensionless form as

$$tr/to = \int_{0}^{to/to} d(t/to) \cdot e^{27{,}200\left(\frac{1}{Tr} - \frac{1}{T}\right)}$$

where

$$\eta = t/to$$

and if

$$Y = e^{27,200\,(\frac{1}{Tr} - \frac{1}{T})}$$

$$tr/to = \int_0^1 Y\, d\eta = \overline{Y} \int_0^1 d\eta = \overline{Y}$$

Using Simpsons rule (Parabolic Rule) for an even number (2n) of spaces in the interval of $\eta = 0$ and $\eta = 1$ yields the approximation to the integration as

$$tr/to = \overline{Y} = \frac{Y_o + 4Y_1 + 2Y_2 + 4Y_3 \cdots\cdots 2Y_{2n-2} + 4Y_{2n-1} + Y_{2n}}{6n}$$

Hence, n can be any convenient integer to insure that an even number of spaces 2n exist between $\eta = 0$ and $\eta = 1$. The equivalent time tr at reference temperature Tr is then exactly equal to

$$tr = \overline{Y}\ to$$

where to is the actual test time.

DESCRIPTION OF INPUT DATA

The following steps must be followed when inputting data:

1. Experimental temperature readings must be taken at equal time intervals, where the number of temperature readings must be odd.
2. The first card for each test series contains the following:

Tn	=	Test number	Cols. 1-12
R	=	Number of temperature readings (always odd)	Cols. 13-24
Time	=	Actual time of test period (min.)	Cols. 25-36
Ref	=	Reference temperature (^{o}R)	Cols. 37-48

3. The next series of cards contain one temperature (^{o}R) reading per card, Cols. 1-12

   There must be R cards in each series.

4. Test number input format is an A field. All other input values must contain a decimal point.

OUTPUT DATA

The program was written to print out the following information:

Actual test time (min.)
Equivalent corrosion time (min.)
Given reference temperature (^{o}R)
List of input temperatures (^{o}R)

A copy of the program and a sample of input and output data sheets follow.

```
C      THIS PROGRAM IS TO DETERMINE AN EQUIVELENT CORROSION TIME AT A
C      PROPOSED TEMPERATURE.  ASSUMING A RATE REACTION OF GRAPHITE
C      REMOVAL THE FOLLOWING PROGRAM WILL ATTEMPT TO SOLVE INTEGRAL
C      BY USE OF SIMPSONS METHOD.
C
C      FLUID FLOW LAB
C
C      LAURALEE MCCUNE
C      INPUT = TEST NO.,NO. OF TEMP READINGS AT EQUAL INTERVALS,ACTUAL
C      TIME OF TEST, REFERENCE TEMP.
C      PROGRAM NO. LM0100
       DIMENSION T(100),Y(100)
    1  READ(5,100)TNO,R,TIME,REF                                        1
  100  FORMAT(A6,6X,(3F12.4))
C      TO DETERMINE LENGTH OF SEGMENT UNDER PARABOLA
       CON =      (1.0/(R-1.0))
       ZREF= EXP(27200./REF)                                            2
       N=R
       DO 5 I=1,N
    2  READ(5,101)T(I)                                                  7
  101  FORMAT(F12.4)
       Y(I)= EXP(-27200./T(I))                                          10
    5  CONTINUE
       Z = Y(1)+ Y(N)
       M=N-1
       DO 7 K=2,M,2
       Z = Z +4.*Y(K)
    7  CONTINUE
       MM=N-2
       DO 9 KK=3,MM,2
       Z= Z +2.*Y(KK)
    9  CONTINUE
       FR =((CON/3.)*Z*ZREF)
       TREF= FR* TIME
       WRITE (6,104)                                                    32
  104  FORMAT(1H1///12X,25HEQUIVALENT CORROSION TIME////)
       WRITE (6,102)TNO,TIME,REF,TREF                                   33
  102  FORMAT (       12X,11HTEST NO. = ,A6, /12X,13HACTUAL TIME =,F8.2/
     112X,17HREFERENCE TEMP. =,F6.0, 6H DEG.R/12X,17HREFERENCE TIME = ,
     2F8.2,5H MIN.///)
       WRITE(6,108)                                                     34
  108  FORMAT(15X,17HINPUT TEMPERATURE//)
       WRITE(6,103)(T(I),I=1,N)                                         35
  103  FORMAT(15X,F12.3)
       GO TO 1
       END
```

EQUIVALENT CORROSION TIME

TEST NO. = 1.0
ACTUAL TIME = 5.00
REFERENCE TEMP. = 4000. DEG.R
REFERENCE TIME = 5.25 MIN.

INPUT TEMPERATURE

2100.000
2700.000
3000.000
4000.000
4500.000
4600.000
4300.000
4000.000
3800.000
3900.000
4100.000

3406

Westinghouse Electric Corporation

CODING FORM FOR IBM TYPE 7090 COMPUTER
FORTRAN - FAP

SAMPLE INPUT

ANALYST	PHONE	DATE	PROGRAM NO.	DECK NO.	L.S. NO.	SHEET OF

STAT. NO. SYMBOL	#	FORTRAN STATEMENT OPERATION	ADDRESS, TAG, DECREMENT	REMARKS	DECK NO.	SEQ. NO.
1 2 3 4 5	6	8 9 10 11 12 13 14	15 16 17 18 19 20 21 22 23 24 25 26 27 28 29	30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72	73 74 75	76 77 78 79 80
1.0		11.0	5.0	4000.0		
2100.0						
2700.0						
3000.0						
4000.0						
4500.0						
4600.0						
4300.0						
4000.0						
3800.0						
3900.0						
4100.0						